

A CCSLM Heuristic for Thinking About Physical Dynamics

Purpose

This note does **not** propose a new physical theory. It suggests a mathematical framework that may be useful when thinking about a recurring problem in physics:

How can a system undergo enormous numbers of transformations, remain stable and observable, and nevertheless exhibit highly nonlinear macroscopic behaviour?

The CCSLM viewpoint suggests separating **local transformation** from **selection of transformation**.

1. Start with composition

Represent a dynamical system as

$$x_{t+1} = F_t(x_t).$$

Rather than assuming that F_t is intrinsically complicated, ask whether it can be represented as

$$x_{t+1} = L_{c(x_t, t)} x_t,$$

where L_i belongs to a relatively simple family of transformations and c is a context/state-dependent selector.

The resulting overall mapping is nonlinear even when every L_i is linear.

More generally,

$$x' = L_n(C_n, x_n) \cdots L_2(C_2, x_2) L_1(C_1, x_1) x.$$

The important distinction is:

transformation complexity versus **selection complexity**.

2. Stability of repeated composition

Repeated arbitrary nonlinear transformations in a high-dimensional state space can generate stretching, folding, sensitivity to initial conditions, attractors, information loss and chaos.

This suggests investigating the converse question:

What classes of transformations remain well behaved under extremely long composition?

One obvious candidate is a class preserving some invariant:

$$\|Lx\| = \|x\|,$$

or more generally

$$\mu(LA) = \mu(A).$$

The determinant-one condition,

$$\det L = 1,$$

is one particularly simple form of local volume preservation.

This should not be taken to imply that physical transformations universally have determinant one. Rather, it suggests asking **which mathematical invariant is actually preserved by the relevant physical state space and dynamics**.

Possible related structures include:

- orthogonal transformations,
- unitary transformations,
- symplectic transformations,
- canonical transformations,
- measure-preserving maps,
- norm-preserving maps,
- conservation-law-preserving transformations.

The question is whether some apparently disparate physical principles can be understood as restrictions on the allowable elementary transformations.

3. Where does the nonlinearity reside?

If the elementary transformations are constrained and relatively simple, complexity must enter somewhere.

CCSLM suggests examining

$$x' = L_{c(x)}x$$

rather than assuming

$$x' = f(x)$$

with f being intrinsically complicated.

The effective nonlinearity can reside in the **choice of L** .

This creates a useful mathematical separation:

simple transformation + state-dependent selection = nonlinear global dynamics

This is closely related mathematically to switched linear systems, hybrid dynamical systems, piecewise-linear systems, automata, control theory and symbolic dynamics.

The physical question is deliberately left open:

Are any apparently nonlinear physical phenomena better understood as consequences of switching between constrained local transformations?

4. Continuous evolution versus discrete selection

A particularly interesting mathematical architecture is

$$\dot{x} = A_{c(x,t)}x$$

or, in discrete form,

$$x_{t+1} = L_{c(x_t,t)}x_t.$$

Here the evolution within a regime can be simple, while transitions between regimes produce complicated behaviour.

This provides a framework for considering possible relationships among:

- continuous physical evolution,
- discrete events,
- state transitions,
- phase changes,
- measurement,
- symmetry breaking,
- quantum state transitions,
- threshold phenomena.

No particular interpretation is implied. The useful question is simply whether **discreteness belongs primarily to the transformation itself or to the selection of which transformation applies.**

5. Information and observability

Another useful CCSLM question is:

What information must survive each elementary transformation for the complete system to remain observable?

For a linear transformation,

$$y = Lx,$$

rank and null-space structure immediately become relevant.

Repeated mappings can progressively remove distinguishability:

$$\text{rank}(L_n \cdots L_2 L_1) \leq \min_i \text{rank}(L_i).$$

Thus a physically meaningful long composition may require mechanisms that preserve particular information-bearing subspaces.

This connects naturally with physical questions concerning:

- conservation laws,
- reversible dynamics,
- phase-space volume,
- quantum unitarity,
- gauge redundancy,
- measurement,
- coarse-graining,
- entropy.

Again, the heuristic is to investigate the mathematics first and determine the physical interpretation afterwards.

6. A possible research program

Rather than proposing new physical equations, one could investigate the mathematical landscape of systems satisfying combinations of:

$$L_i \in \mathcal{C},$$

where $\mathcal{C}$ is a constrained transformation class,

$$\mathbf{x}_{t+1} = L_{c(\mathbf{x}_t, t)} \mathbf{x}_t,$$

with state-dependent switching, together with requirements such as

$$\det L_i = 1, \quad L_i^\dagger L_i = I, \quad L_i^T J L_i = J,$$

or other invariant-preserving conditions.

Then ask:

1. What forms of macroscopic nonlinearity can emerge?
2. Under what switching rules does chaos occur?
3. Which invariants survive arbitrary switching?
4. When does switching destroy observability?
5. What classes of attractors are possible?
6. How much complexity can be generated by the selector alone?
7. Can apparently nonlinear dynamics be decomposed into simple transformation + selection?
8. Which familiar physical systems naturally admit such decompositions?

These are mathematical questions before they are physical claims.

Closing thought

The central heuristic is deliberately modest:

Do not assume that observed nonlinearity implies intrinsically nonlinear elementary dynamics. First determine what kinds of simple transformations can survive repeated composition, and then investigate whether complexity can arise from their selection, ordering, constraints and interactions.

If this viewpoint has any physical value, the mathematics should reveal it.

If it does not, the mathematics should also reveal that.

That is the intended role of the CCSLM framework: **a question about the structure of composition, not a proposed answer to fundamental physics.**